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AUTHOR	Dupuis, Mary M., Ed.; Mitzel, Harold E., Ed.
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ABSTRACT

A planning conference on technology in education resulted in specific recommendations to the National Institute of Education (NIE). 1) Technology offers the potential for amplifying individuality, expanding the scope and depth of the educational process, contributing system studies towards goal definition, and improvements in quality, equality of opportunity, and cost control. 2) Possible areas of prime concern to NIE include the lower elementary grades, two year colleges, open universities, system studies, educational dynamics (model building and simulation), and technology development and evaluation. (Author/RH)

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TECHNOLOGY IN EDUCATION

Report of a Planning Conference
for the NIE Planning Unit

July 29-30, 1971

Washington, D.C.

John G. Castle, University of Alabama-Huntsville and Stanford University
Frederick C. Frick, MIT Lincoln Laboratory
William H. Huggins, Johns Hopkins University
David C. Miller, Polytechnic Institute of Brooklyn
Bernard M. Oliver, Hewlett-Packard Co.
Kevin H. Smith, Education Development Center
John G. Truxal (Chairman), State University of New York, Stony Brook

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NATIONAL INSTITUTE OF EDUCATION
Planning Unit

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Edited by Mary M. Dupuis, Ph.D.; Harold E. Mitzel, Ph.D., Project Director, College of Education, The Pennsylvania State University.

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TECHNOLOGY IN EDUCATION

POSSIBLE CONTRIBUTIONS OF TECHNOLOGY

Technology can contribute significantly to education if the new technology is carefully researched and developed, if it is matched to the characteristics of both the learners and the teachers, and if appropriate test and evaluation procedures are carried out. Each of these three conditions must be a major concern of any organization responsible for encouraging educational innovation through the use of technology to assist the learner and teacher and to control the cost of the educational process.

If these conditions are met, what can we anticipate from technology in education?

1. Technology can amplify individuality. Technology is essential if we are to have economical individualized instruction at all educational levels. In the elementary and secondary schools, technology can be used to guide the learning process on an individualized basis while the teacher works personally with the single student or small group. At all levels, technology is essential if we are to mass markets sufficiently to justify the economic and talent costs of preparing individualized materials. Even the Open University of the United Kingdom, with its 25,000 students, represents severe problems of cost per student unless the materials prepared can be used by a larger group. The Empire State College (New York's version of the Open University) is planning for students in the hundreds rather than thousands.

The computer provides particularly promising opportunities for individuality–not only through computer-assisted instruction with branching programs to tailor the material to individual needs, but also in confidential student self-evaluation. Whereas social applications of computers often raise serious questions of the invasion of privacy, computers and technology in education offer the opposite opportunity if the application is guided by appropriate system planning.

2. Technology provides the opportunity for expanding the scope and depth of the educational process. With our recognition that learning also occurs outside the classroom, technology can carry education beyond the school to the home and community. Commercial television has demonstrated dramatically the impact of modern communication technology on the pattern of human life; educational technology, with its breadth of communication and computer capability, has as yet had little analogous effect beyond singular accomplishments such as "Sesame Street" and the "Civilization" series.

The scope of television offerings in the home has been limited by the small number of broadcast channels, the costs, and the resulting demands for a large audience. The limitations promise to be eased with the expansion of cable television, the availability of low-cost video cassettes and the provision of computing capability in the home through telecommunications.

3. Technology in its broadest sense can contribute system studies to assist in defining specific and measurable goals, to permit comparison of alternatives, and to provide evaluation in terms of both quality and cost. In other words, the methods of modern technology, involving the concepts of modelling and quantification and subsequent decision-making, can increase our understanding of educational systems and guide decisions by students, parents, teachers, school administrators, and government officials aimed toward educational improvement.

Even though system studies in education are severely handicapped by our lack of understanding in major areas of learning theory and evaluation, the possibility for significant progress still exists because of the current receptivity of education to experimentation. Spurred by the specter of rapidly rising costs and widespread dissatisfaction with current practices and procedures, educators across the country are seeking new approaches, new school organizations, and new ways to motivate students.

4. Finally, technology can provide a wide variety of devices and small systems which offer the promise of improved quality, better opportunity for the culturally and geographically disadvantaged, and cost control through resource management. In the following sections, we shall mention a sampling of this technology which is evolving often as a by-product of the recent revolutions in electronics, communication, computers, and systems engineering.

The group emphasizes that technology can be expected to ameliorate, but not to solve, the problems of education. Technology can enrich the role of the teacher, but the teacher (with support systems) still remains the key element in the success of the educational process. Technology can provide the student access to the knowledge "banks;" it supplements and broadens the experience of the student, but the home, community and school environments will remain primary determinants of educational success. Thus, both facets of technology (system studies and devices) must be viewed as means toward improving education, but means definitely subsidiary to the fundamental essentials of social change and improved educational opportunities for teachers.

In this respect, education is similar to many of the urban and social problems of dominant national interest today. For example, both the health and educational status of young people in the central city are intimately related to all factors contributing to the "quality of life" for these people: the urban environment, job opportunities, crime, housing, welfare policies, transportation, and family and community life. Technology applied to education alone certainly cannot overcome the difficulties inherent in the total system; technology does offer an approach to ameliorate the situation for at least certain individuals and does constitute an important element in a total program.

INITIAL CONCERNS OF NIE

The R&D program of NIE should encompass all areas of education from early childhood to gerontological. The program, responsive to promising and imaginative ideas, must above all involve outstanding researchers drawn from all relevant scholarly disciplines. The impact of the National Science Foundation curriculum projects over the past fifteen years has demonstrated emphatically the importance of the intellectual quality of the researchers and innovators and the significance of actively involving outstanding individuals from outside the mainstream of education.

Beyond the generality, however, these areas seem particularly promising for the NIE:

1. Lower elementary grades (K-3). Our impression is that the federal program in early childhood is moving in exciting and promising directions. Success here to any meaningful degree will place even greater emphasis on ages 5-8. In these years, furthermore, the cognitive skills where technology seems especially helpful are very important. We include here not only the occasional high-technology contribution (as in computer-assisted instruction or computer-controlled typewriters and "television" screens for teaching reading), but such low technology as appropriate sequences of games requiring mastery of basic reading, arithmetic, and logical reasoning processes. Such games can teach the skills necessary to begin understanding algorithmic approaches (the concept of a set of rules by which any problem in a class can be solved).

Within the lower elementary grades, technology can also begin to provide the motivation for student learning. By selecting technological devices by which the student is naturally fascinated, we can also begin to lay the foundation for vocational training which in later years can continue to provide motivation for classical subjects in parallel with career preparation.

2. Two-year colleges. The rapid enrollment increases anticipated in this decade in the two-year colleges make savings a feasible goal of technology, without the difficulties inherent when there is an existing surplus of teachers and a steady or declining total enrollment. Indeed, shortages of qualified faculty exist in several fields for the two-year colleges.

Furthermore, here the importance of vocational training suggests the exploitation of technology, particularly in the light of the success and current directions of the military and industrial training programs. Indeed, an immediate contribution of NIE could be in the evaluation of such training programs and the dissemination of information about them. The accomplishments of Project 100,000 (the Army program to absorb 100,000 men not educationally qualified) are not widely known in education.

Finally, NIE should play a leadership role in the evolution of the "open-university" concept in this country; it seems clear that this effort could be related initially to innovation at the educational level of the two-year colleges since many of the open-university students will parallel those in the two-year college system. Furthermore, there will be more opportunity for innovation in the two-year college, with its growing enrollment.

In all three areas, technology not only provides a richer educational experience, but it can also furnish strong motivation for learning by focussing on experiences drawn from the student's technological environment—particularly as education moves out of the school and as students seek purposeful goals within the schools.

SYSTEM STUDIES

System analysis and design techniques provide the basis for the consideration of various possible models for the educational process—models which are clearly level-sensitive (i.e., dependent on student age and educational objectives). These models range from the familiar teacher-centered classroom to totally individualized study including experiences in the community (such as are now being tested by secondary schools and colleges). Probably most important for the future are models which fall between these two extremes—structures in which the total educational program includes both individualized learning and formal classroom work.

In the interpretation of these models, the R&D must encompass both curricular materials and staffing needs. In curricular materials, we include modules of all magnitudes and all forms—including textbooks, of course, but also encompassing educational kits, games, project activities, and so forth. Any particular system model can only be successful if the quality of these curricular materials is high.

Research is required on the cost problems associated with materials. The present cost of elementary-secondary education is about one dollar per student hour with typically 85 percent of this in salaries, about 50 percent in teacher salaries. If the goal is to hold costs within this figure, curricular materials are severely limited—particularly in a period of level enrollments and an oversupply of teachers when we cannot expect to increase student/teacher ratios without serious objections from the teacher organizations. For this reason, the area of special education for the retarded, handicapped, etc., is a more promising immediate market: the cost here is five to six dollars per student hour, programs are limited, and there is no surplus of specially trained teachers. Furthermore, the opportunities for technology are often clear, particularly when student self-pacing is important.

Research is needed on distribution problems for curricular materials. Many of the national curricular projects have encountered difficulties because of the established relationships between school systems and the commercial publishers (who are naturally book-oriented). Major publishers experience difficulties in marketing low-cost items. The problems of distributing low-cost trade paperback books are not tolerable in the educational market. With trade books, the cost is kept low by the local outlet's accepting the books sent by the distributor. In education, schools insist on ordering specific books; the cost per book then has to be high. Furthermore, the publishers often cannot readily handle low-cost equipment items or provide service for larger items of equipment.

Finally, research is needed on how to establish incentives which will encourage outstanding educators to devote the time and energy needed to develop curricular materials. In the case of textbooks, the incentives are clear and widely accepted; the author receives royalties and prestige. In CAI, for example (although films and other materials can also be used), the very poor quality of much of the material currently available is certainly in large measure the result of the poor incentives. With the present confused copyright laws and their uncertain future, outstanding educators are not encouraged to invest major efforts in computer program or educational materials development. Yet the success of much of educational technology depends on the involvement of these relatively scarce leaders. The problem is increasingly serious because of the ease of copying printed material.

Finally, the computer-program problem is additionally complicated by the incompatibility of different computers. A similar incompatibility exists in television tape equipment and threatens to evolve in television cassettes for home or school use. This entire issue of standardization, while neither glamorous nor exciting theoretically, is of such basic importance that it should be a concern of NIE.

The system studies must also encompass teacher training problems. How are teachers to be trained to be managers of the "classroom" system and its resources, rather than only lecturers or recitation leaders? What are the feasible approaches in pre-service training? How can technology be beneficially used in this life-long training process for teachers?

If one views the above comments on system analysis in education, they comprise a call for a study of the total educational system: school organization and management, curricular materials, teacher-student relationships, teacher training, in-school and out-of-school programs, etc. Such a study might well be compartmented according to educational level, but even the study of a single level (such as grades 13-14) would require a research program beyond the capabilities of most universities or industrial research centers.

EDUCATIONAL DYNAMICS

The complexity of the system problems in education at all levels suggests that a central effort of NIE should be a system-modelling research program—an attempt to develop first a model for a severely restricted portion of education, but a model which could then be expanded to describe more and more of formal education. The broad objective of such a model would be to provide logical bases for local, state and national policy on educational matters. Secondary objectives, compatible with the above, would include guiding research, testing, and evaluation in the comparison of different organizational models, local or regional studies of particular problems, and studies of special sub-systems (such as the education of the physically handicapped). A major output of such an effort might be a means for fostering diversity according to individual and community needs and desires.

The precedent for such a model has been established in the work of the last decade in computer simulation, recently reaching into the study of social, national, and international systems. The educational system seems particularly appropriate for a model analogous to those developed by Jay Forrester and his associates at MIT and reported in their three books *Industrial Dynamics, Urban Dynamics,* and *Global Dynamics.**

Urban dynamics essentially represents a postulative model. One postulates quantitative relationships among the hundreds of significant variables in the model for a city (which is restricted to housing, types of industry, and types of workers, each broken into a few classes, with the allowable policies encompassing housing, job training, and welfare). From such a model, one can study the effects of different starting conditions and alternative policies on the future development of the city.

Defense and space systems are often modelled statistically, rather than postulatively. That is, from the study of previous measured performance of individual components of the system, one determines the best quantitative or mathematical description for the relationships among the system variables. Such statistical modelling depends upon meaningful past measurements of sub-system performance—data which are often not available in education.

While the models found in urban dynamics do not give the optimum solution to a particular city problem, the model and simulation use the computer to extend human understanding to very complex systems. If one accepts the premises that any model of a significant social system must be a gross simplification, and the closer the model comes to the actual system, the more valuable the simulation studies, then the ability of the computer model to extend man's mind toward more realistic simulations is the most important impact of modern technology. It is also an application which so far has not impinged on educational research. Thus, this group proposes enthusiastically that the in-house capability of NIE have as a central element an "educational dynamics" research program.

This primary recommendation of our meeting has several important ramifications:

1. One direct value (to NIE) of such a program would be the need for truly outstanding scholars if the simulation were to be useful.

2. The program would be exceedingly attractive to excellent men, and the first problem of recruiting full-time staff for NIE would be overcome.

3. Once underway, the program would be a major attraction for the involvement of outstanding scholars on a part-time basis in NIE activities.

4. The program would permit NIE utilization, ultimately, of such resources as the American Council on Education data on student achievement in higher education and the national measurements of student achievement.

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*Cambridge, Mass.: The M. I. T. Press. 1961, 1969, 1971.

5. The simulations would be a basis for public relations on a high level, for a service to the Executive and Legislative branches of government (federal, state, and local), and for planning with teachers' organizations and others. Such an NIE program would add a totally new dimension to educational R&D.

TECHNOLOGY DEVELOPMENT

In the area of technology development, the most important national need is for an evaluation of what has been done and what is now underway—an evaluation which includes cost studies as well as measures of educational results, including student and parent satisfaction, as definitive as possible within the present state of knowledge. Such evaluation requires visits to schools, since final reports and published, professional papers seldom give substantive interpretations. The Technology Group wishes to emphasize strongly this key role for NIE and the associated importance of the capability of the regular staff of the Institute.

In terms of specific educational technology (devices and systems), the research potential can perhaps be illustrated merely by a brief list of existing technology which seems likely to be significant in the near future:

1. Audio communication and audio-visuals. The use of audio cassettes with printed workbooks or slides is relatively unexploited in education in spite of the rapid growth (into the millions) of cassette players in public use. (The audio cassette is especially important because of the low cost, the appeal to young people, and portability, and the unique standardization which has been achieved.) A number of film strip-cassette players are now commercially available, although again without standardization or compatibility and still with small total sales—two reasons for the paucity of high-quality educational materials. This is an excellent example of an instance in which governmental support is essential to overcome the negative feedback arising when sales are low because good materials are unavailable; good materials are not generated because sales are low.

2. Microfiche technology permits the production of teaching machines of a new magnitude of effectiveness. The possibility of low-cost display on a screen promises home availability and a technology-man interface already familiar to the student at any level. The importance of this last point must not be underestimated. If the new educational technology is to be accepted by the individual in a self-paced, individualized mode, the display mechanism must be familiar to the student or at least not terrifying.

3 Cable television promises the "wired city" within a few years on at least an experimental basis, and satellite transmission to the Colorado region is currently being developed for medical and educational purposes. While several channels are likely to be allocated for education, there has been inadequate study of how to elicit interactive learning (e.g., as an economical substitute for the unattainable quality and creativity levels required to hold an audience in the non-interactive mode). Research is needed on the design of low-cost (i.e., less than one hundred dollars) attachments to television receivers to permit minimal storage at the receiver and listener interaction without expensive two-way transmission. Thus, one can visualize the system of the future in which an educational program is transmitted on cable to the home television receiver. The small "computer" there allows the student to control the program development by his responses to specific questions, with no necessity for transmission from the home back to the central office.

4. Computer applications in education have emphasized use in management-administration and CAI. The optimum design of an educational computer for student use in simulations, "laboratory" work, and extension of experiences needs to be undertaken, especially as we begin to understand how computer simulations can enrich education and encourage the student to experiment on a "modelled world."

5. The technology of recording moving visual images has developed to a very high level, particularly for motion picture film. No matter what future technological developments may be made, images recorded on film now will transfer to new technological systems with no loss of quality. For instance, motion pictures recorded by Lumiere in 1895 may be seen currently with no loss of quality; may be transferred to video-tape, 8mm film, or whatever; and will continue to be useful, at least historically, for generations to come. This suggests that a contemporary thrust toward the visual recording of "classical events" should be mounted for an ever-widening spectrum of fields of interest. "Classical events" means such things as the physical signs

used in medical diagnosis. The signs of right heart-failure have not changed in thousands of years and are not likely to soon, even though the treatment and understanding of the meaning of them advances very rapidly.

The Education Development Center's seven-year project for the recording of the ancient culture of the Netsilik Eskimo is a case in point. Nearly eleven hours of edited sound film covering the main events in a year's cycle of this "Ice-Age" culture were prepared without any use of English commentary. NIE should assess the value of this approach and initiate support of viable production of such materials.

These five areas are merely representative of the broad range of potential now essentially unexplored in any logical way. To these we could add the previously mentioned gaming approach (a pair of dice or deck of cards represents some of the most attractive educational "technology") or the use of technology in "vocational" applications K-12.

Regardless of the specific technology, however, attempts to introduce innovation in this way encounter certain poorly understood barriers:

1. How do we obtain educational materials of truly outstanding quality (the problem of incentives)?

2. How can the federal government ensure development and production of high-quality technology when the potential market is so fragmented and uncertain, when relations with industry are constrained by patent and contracting policies, etc.—the problems identical to those encountered in the health field?

3. How can we effect distribution of a wider variety of learning aides in a system geared primarily to books?

4. How is evaluation to be accomplished?

These questions should be major concerns of NIE's R&D program.

CONCLUSION

This report is an attempt to summarize the important ideas of the two days of group discussion, rather than to present a series of recommendations unanimously approved. The report has been prepared by the chairman and attempts to incorporate specific suggestions from the members on an earlier draft, but it has not been reviewed or approved by the members.

The report is purposely restricted in scope and pragmatic in outlook. While the discussions touched frequently on fundamental goals for education, sociological constraints and the impact of educational innovation, and psychological considerations, the report is restricted to those aspects directly related to technology.

Furthermore, the report attempts to focus on specific recommendations to NIE, rather than on broad deliberations on the role of technology. The group focused on the problem of what the early program of NIE should be—specifically what meaningful programs could be launched at once. These programs clearly should represent a compromise between short-range and long-range efforts. The viability of any new governmental institution will depend on short-term (two-year) results which are politically and professionally attractive and which have a high public visibility. The foundations for the future contributions and stature of NIE are built, however, on the basic research, long-term programs, where the only visibility may well be the recognition of the program area and the early results in the technology assessment studies which are so important to any societal research and development effort.